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INSTRUCTION MANUAL

FOR

MINISERVO®

PROCESS RECORDER

MODEL MSR-3

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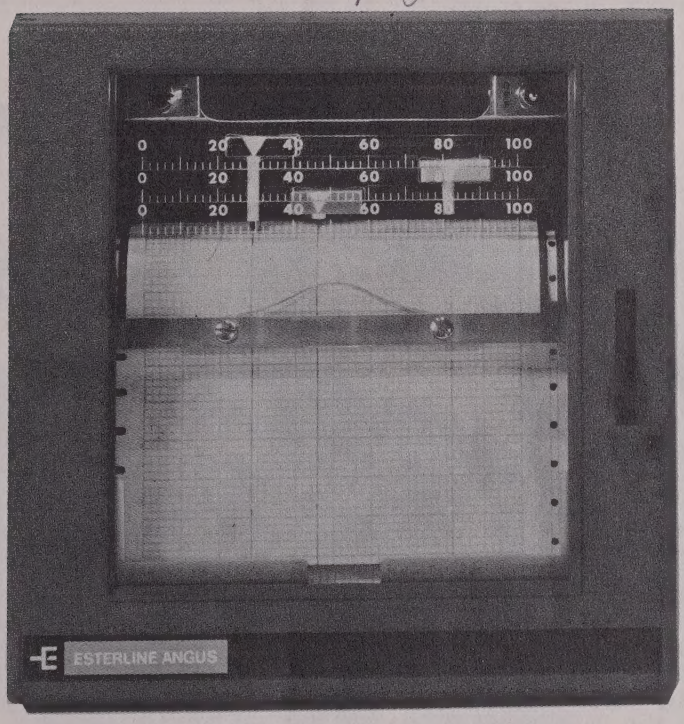

ESTERLINE ANGUS

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SECTION 1 - INSTRUMENT DESCRIPTION

1.1 INTRODUCTION

a. The Esterline Angus MSR series of Miniservo strip-chart recorders has been specifically designed for industrial process control and monitoring applications. These compact instruments may be configured to provide one, two, or three independent analog-measuring channels. The single-channel recorder is identified as Model MSR-1, the two-channel recorder as Model MSR-2, and the three-channel recorder as Model MSR-3.

b. Each servo-controlled recorder channel is capable of continuously measuring, indicating and recording the analog variable from any process sensing device that delivers a DC signal within the measurement span of that particular channel. In multi-channel recorders, the different colored traces are permitted to overlap (crossover) during operation so that the full chart width is utilized for maximum readout resolution.

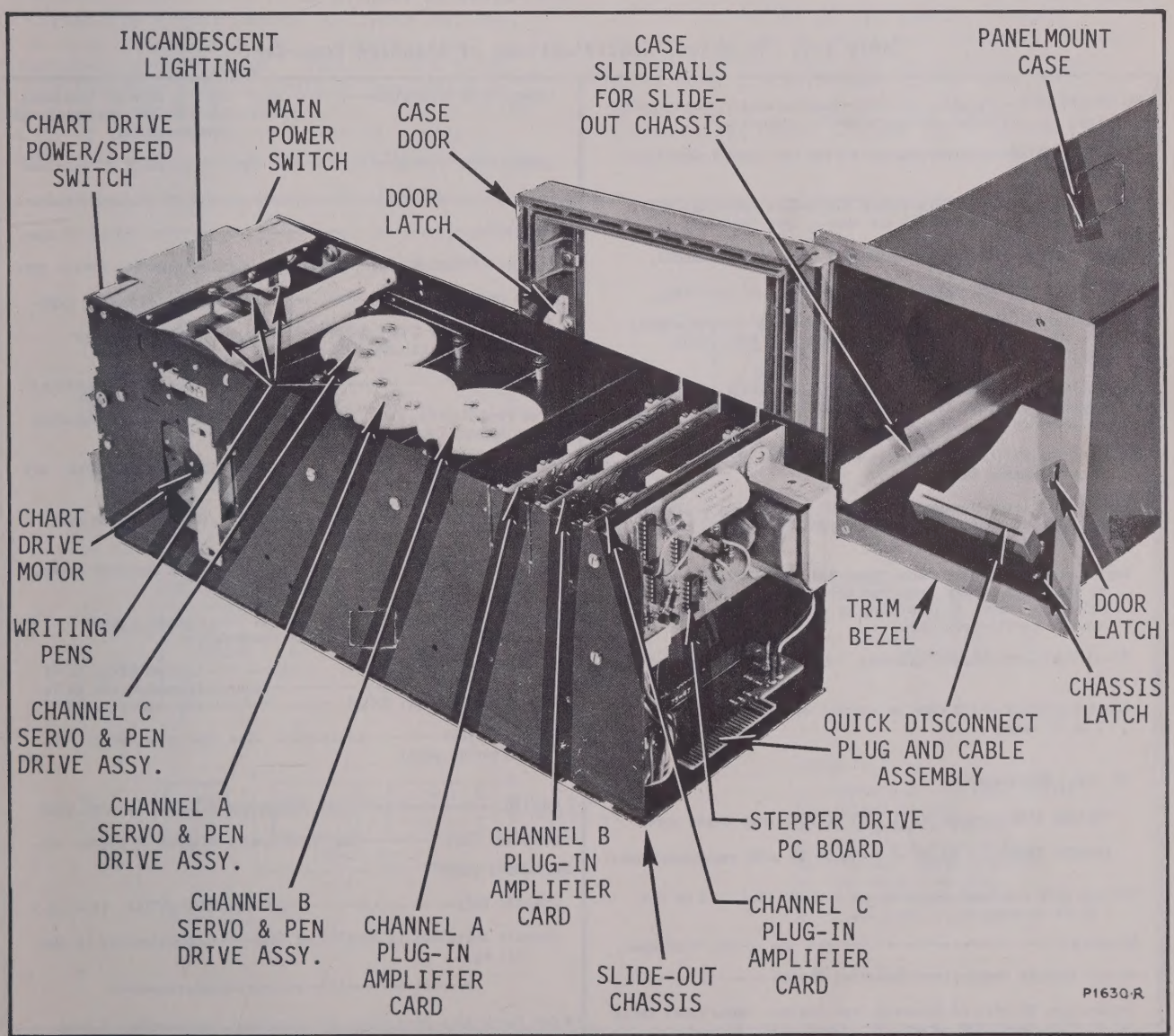


Figure 1-1. Major Components of Miniservo Recorder (Model MSR-3 shown).

c. The electro-mechanical measuring system of each channel is modular constructed on plug-in electronic PC card assemblies and on mechanical subassemblies to provide ease in operating and servicing the recorder. The electronics and mechanical servo systems including all channels are mounted on a single pull-out chassis which slides into a panel-mount aluminum case. All electronic calibration adjustments for each channel are conveniently located and easily accessible by extending the recorder chassis from the panel-mount case. By detaching a quick-disconnect plug and cable assembly from the rear of the chassis, the entire chassis can be completely removed from the case (see Figure 1-1).

d. The writing system of each channel features a single disposable pen-and-ink cartridge. Each sealed cartridge delivers a minimum of 3600 feet of trace. In a multichannel recorder, different color inks are used to distinguish between the channel traces. In a single-channel recorder (Channel A), red is the standard color. In a two-channel recorder, red is used for Channel A and black for Channel B. In a three-channel recorder, red is used for Channel A, black for Channel B and blue for Channel C.

1.2 SPECIFICATIONS

Electrical and mechanical characteristics for recorder models MSR-1, MSR-2 and MSR-3 are listed in Table 1-1.

Table 1-1. Technical Specifications of Standard Recorder.

INSTRUMENT TYPE---Panelmount, strip-chart graphic recorder with one, two, or three analog recording channels.

RECORDING SYSTEM---Servo-actuated inking pen (per channel) on chart paper.

Method of Writing---Cable-driven disposable cartridge with integral writing pen and ink supply (per channel).

Step Response Time---0.5 second full scale (per channel).

Pen Lifter---Manual lever provided on front of recorder.

Charts---Z-fold, rectilinear, with 10 cm active span width; 20m long with 5 cm folds; left hand zero and metric calibration.

Scaleplate---Removable, clear plastic see-thru scaleplate with segments provided for each channel. White numerals. Calibration for left-hand zero.

MEASURING SYSTEM (Each Channel)---Null-balance DC servo with potentiometric input.

Servo Amplifier---Separate plug-in PC cards using solid-state operational amplifiers with chopperless design. ±100V DC overload without damage.

Amplifier Adjustments---Gain, Span and Zero controls mounted at top of amplifier cards and are accessible for adjustment while instrument is operating by sliding chassis out of case to service position.

Electrical Zero---Left-hand zero, ±50% Offset adjustment.

Input Impedance---250 ohms on current span. 1 megohm for 1 to 5V span.

DC Input Measurement:

VOLTAGE SPAN ---0-5V DC (1 - 5V DC with suppressed zero.

CURRENT SPAN--- 0 to 20 mA (4 to 20 mA with suppressed zero).

Maximum Safe Overload---150V DC on 1 to 5V span. 40 mA for 4 to 20 mA span.

Accuracy----------±0.5% of span.

Normal Ambient Temperature Operating Range--------10 to 45 °C.

Temperature Effects on Accuracy Over Ambient Temperature Range (10-45 °C)-----±0.03% of span/°C. (maximum)

Common Mode Rejection----------DC: 120dB @ 100V DC (maximum).
AC: 100dB @ 50V (maximum) RMS line frequency.

Common Mode Voltage----------120V AC or ±150V DC (maximum)

Deadband----------0.2% of span (maximum)

Resolution----------0.1% of span.

Feedback Potentiometer---Sealed, conductive plastic, rotary type.

Servo Motor----------Sealed, permanent magnet, DC rotary type.

TWO-SPEED STEPPER CHART DRIVE----DC stepper motor and pulse-generating circuitry synchronized to line frequency.

Stepper Motor----------27V DC (5 1/3 rpm, 40 Hz maximum)

Slow Feed Rates---1.25, 2.5, 5 or 10 cm/hr. Any one selectable by manual jumper wire. *

Fast Feed Rates---15, 30, 60, 150, 300, 600, or 1200 cm/hr. Any one selectable by manual jumper wire. *

Control---Front mounted, 3-position, toggle-type switch with Off, Slow, and Fast positions.

Transport Features---Front loading, dual-ended sprocket drive, slide-out chart tray, and chart tear-off bar.

POWER REQUIREMENTS---115V ±10%, 60 Hz. Dual primary power transformer provided for each channel.

Single-Channel Model MSR-1 ----------Approximately 16 VA.
Two-Channel Model MSR-2 ----------Approximately 23 VA.
Three-Channel Model MSR-3 ----------Approximately 30 VA.

FUSE PROTECTION----------Replaceable line fuse provided on rear connection panel.

LIGHTING----------3 incandescent lamps; ¼A @ 6V each.

INSTRUMENT SIZE----------See dimensioning diagram in Figure 2-1.

INSTRUMENT WEIGHT:

Chassis Only----------Approximately 14 lbs. (6.3 kg.)

Chassis Installed in Panelmount Case-----Approximately 18 lbs. (8.1 kg.)

****

* See instrument Data Sheet for slow/fast combination of feed rate supplied.

1.3 THEORY OF OPERATION

The complete measuring system, representative of each channel employed in the Miniservo III recorder, is illustrated in the simplified block diagram of Figure 1-2. Only the basic servo measuring system is described herein.

1.3.1 SIGNAL INPUT

Analog signals to be recorded are first applied to an input filter and signal limiter network on the servo amplifier PC card. This network rejects stray interference and includes a pair of zener diodes for input overload protection.

1.3.2 PREAMP

a. After the signal leaves the input network, it is next preamplified by a chopperless, integrated-circuit opamp. Gain of this stage is regulated by span-determining resistors R_a and R_b in a closed feedback loop. The selected values of these resistors maintain a nominal preamp output of 0 to 1 volt, regardless of the basic input signal range. The Voltage Comp potentiometer is used to compensate for op-amp offsets over the normal operating limits of the stage.

b. The preamp output signal (E_s) is next fed to a voltage summing network. In addition to E_s, the summing network also receives two other voltages--a gain-regulating voltage e_g derived from a feedback circuit in the servo amplifier loop, and a zeroing voltage E_z that is established by the regulator network and Zero Opamp circuits. A ±50% zero adjustment is standard.

c. At the output of the summing network, zeroing voltage E_z and gain-regulating voltage e_g are combined with the preamplified signal E_s to form a conditioned signal voltage e_c. This resultant signal is then applied to a Differential Opamp circuit which is the first stage in the closed loop servo system.

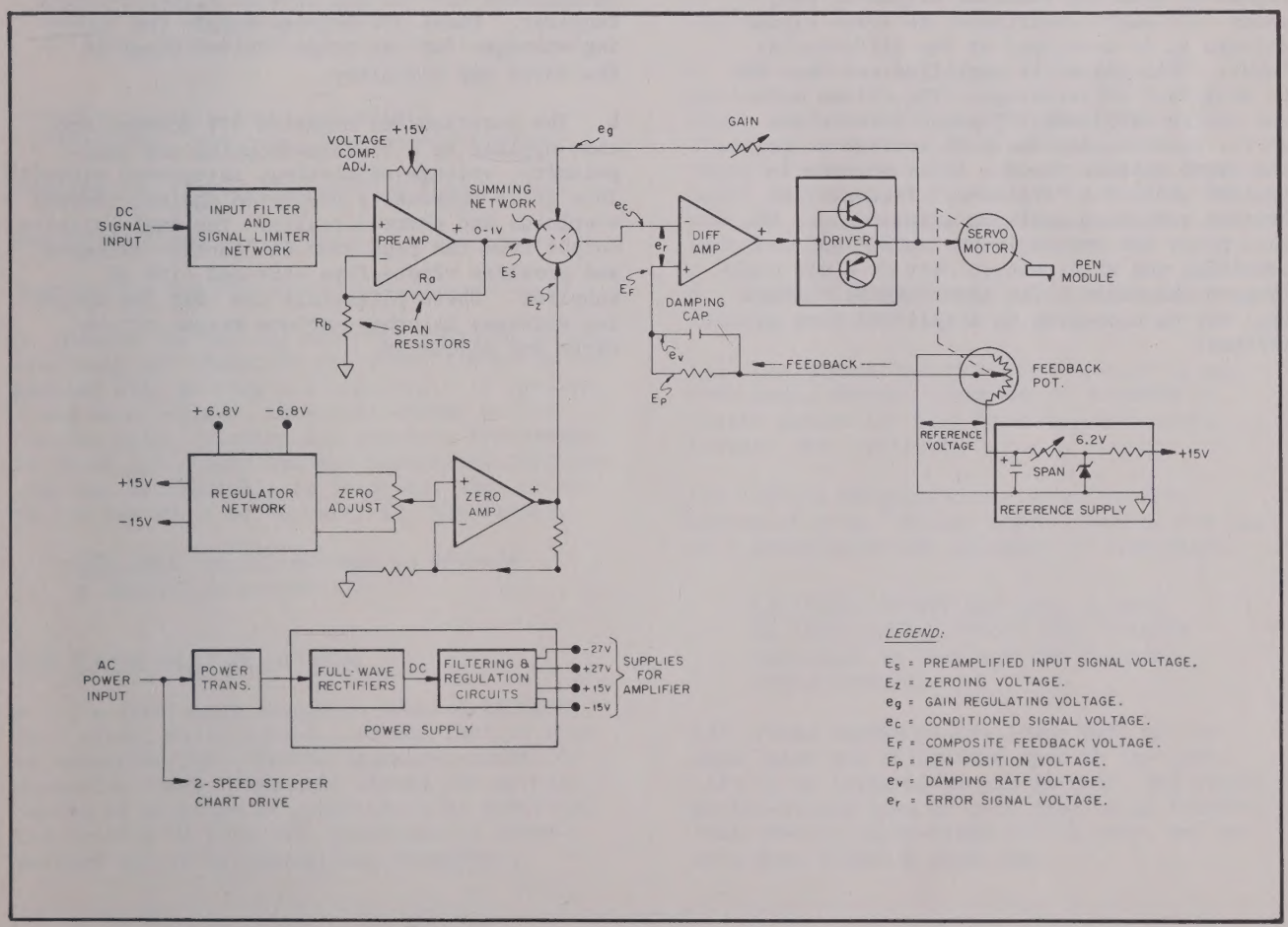


Figure 1-2. Functional Block Diagram (Typical Per Channel).

1.3.3 SERVO AMP

a. Signal voltage e_c from the summing circuit is connected to the inverting input of the Differential Opamp. The non-inverting input of this opamp receives a composite feedback signal E_f, which is made up of voltages E_p and e_v. Voltage E_p is directly proportional to the position of the wiper arm on the feedback pot (equivalent to pen position). A damping rate voltage e_v is also picked off at the arm of the feedback pot through a signal differentiating capacitor. This dynamic voltage depends upon the velocity of the servo motor and serves to bring the servo motor to the correct stopping point. The value of the damping capacitor has been selected for optimum response characteristics.

b. The Differential Opamp compares the analog signal e_c with the feedback signal E_f and, under "off-null" conditions, an error signal voltage e_r is developed at the differential input. This signal is amplified and then fed to an output driver stage. The driver makes use of two complementary power transistors which, in turn, deliver a DC voltage to power the servo balance motor. Drive voltage is applied until the "follow-up" feedback pot reaches a voltage position equal to e_c. At this point the system is "balanced" and the recording pen will come to rest at a new position on the chart. The error signal voltage (e_r) may be expressed in simplified form as follows:

$$e_r = [E_s \pm (E_z + e_g)] \pm (E_p + e_v)$$

or:

$$e_r = e_c \pm E_f$$

c. Reference voltage for the feedback pot is derived from an adjustable, temperature-compensated reference supply circuit. In this supply, a ±15V source is divided down, zener-regulated, and filtered to provide a 6.2V reference source. An adjustable Span control is provided for calibration of the recording span.

1.3.4 POWER SUPPLY

a. The power supply for each channel's servo measuring system is applied through a dual-primary, step-down transformer that may be operated from a 115V (±10%), 60 Hertz line supply. The stepped-down secondary voltage of the power transformer is applied to a full-wave, bridge-type, rectifier circuit that provides unregulated +27V DC and -27V DC filtered-output supplies. These 27V sources supply the operating voltages for the output driver stage of the servo amp circuitry.

b. The positive and negative 27V sources are also applied to a voltage-dropping and dual-polarity, voltage-regulating, integrated circuit. This IC is internally protected against thermal overloads and short circuits. The dual-polarity output from the regulator is further filtered and provides ripple-free +15V and -15V DC supplies. These potentials are used for operating voltages in other various stages of the servo amp circuitry.

SECTION 2 - INSTALLATION

2.1 UNPACKING INSTRUCTIONS

a. Carriers are responsible for damage in transit. If the packing case shows damage, make a notation to that effect on the express receipt or freight bill. If the shipment within is damaged, notify the carrier and your Esterline Angus representative immediately. The following standard items have been inspected and carefully packed in the shipping carton.

ITEM	QTY.
Panelmount Case with Attached Panel Clamps and Trim Bezel (With Attached Door Assembly)	1
Recorder Chassis Installed Within Panelmount Case	1
Service Kit (Inking Accessories)	1
Recording Chart	1
Instruction Manual	1

b. Remove the packing material from the carton carefully and check off all items listed on the packing slip as they are unpacked. If special items were ordered, they will appear on the packing slip. Inspect all contents for damage. If there are electrical and mechanical deficiencies not attributable to shipping, then refer to the statement of Warranty in this manual.

> CAUTION: DO NOT attempt to operate a damaged instrument.

2.2 CASE INSTALLATION

a. The instrument should be mounted upright in a clean, well-lighted location that is free of excessive dust, steam, moisture, smoke, or corrosive fumes. The unit should not be subjected to extremes of temperature or humidity. The cooling of internal components is accomplished solely by convection; therefore, installation of the instrument must provide for adequate air circulation. In addition, it should not be mounted close to large transformers or near conductors carrying high currents.

b. The depth of the case is 20" (508 mm) from the back surface of its mounting flanges. Space behind mounting flanges (including the mounting panel thickness) must be sufficient to accommodate this dimension; also, if necessary, allow additional space for wiring. Allow 18" (457 mm) minimum clearance in front of the panel for chassis insertion, removal, operating, and servicing procedures.

c. For installation other than in racks with removable panels, clearance must be available above and below the case to permit mounting. The upper and lower panel-mounting clamps supplied with the case are suitable for use on panel thicknesses up to 3/16" (4.76 mm). The overall case dimensions and panel cutout dimensions are given in Figure 2-1.

d. MOUNTING PROCEDURES: Mount instrument as follows:

(1) Use dimensions shown in Figure 2-1, and form panel cutout. Case can be mounted on sloped panels 15° back from vertical or 15° forward from vertical.

(2) Remove shipping screw assembly from bottom of case. Retain screw assembly for use in a possible future shipment of instrument.

> CAUTION: DO NOT tip case forward at sharp angles (>15°) with chassis installed in case and the shipping screw removed.

(3) Press inward on the lower part of the door latch and swing door open to the left. Lift up on lower-hinge pin in door, and remove bottom-hinged side of door from hinge bracket. Pull down on upper-hinge pin in door, and remove door assembly from case.

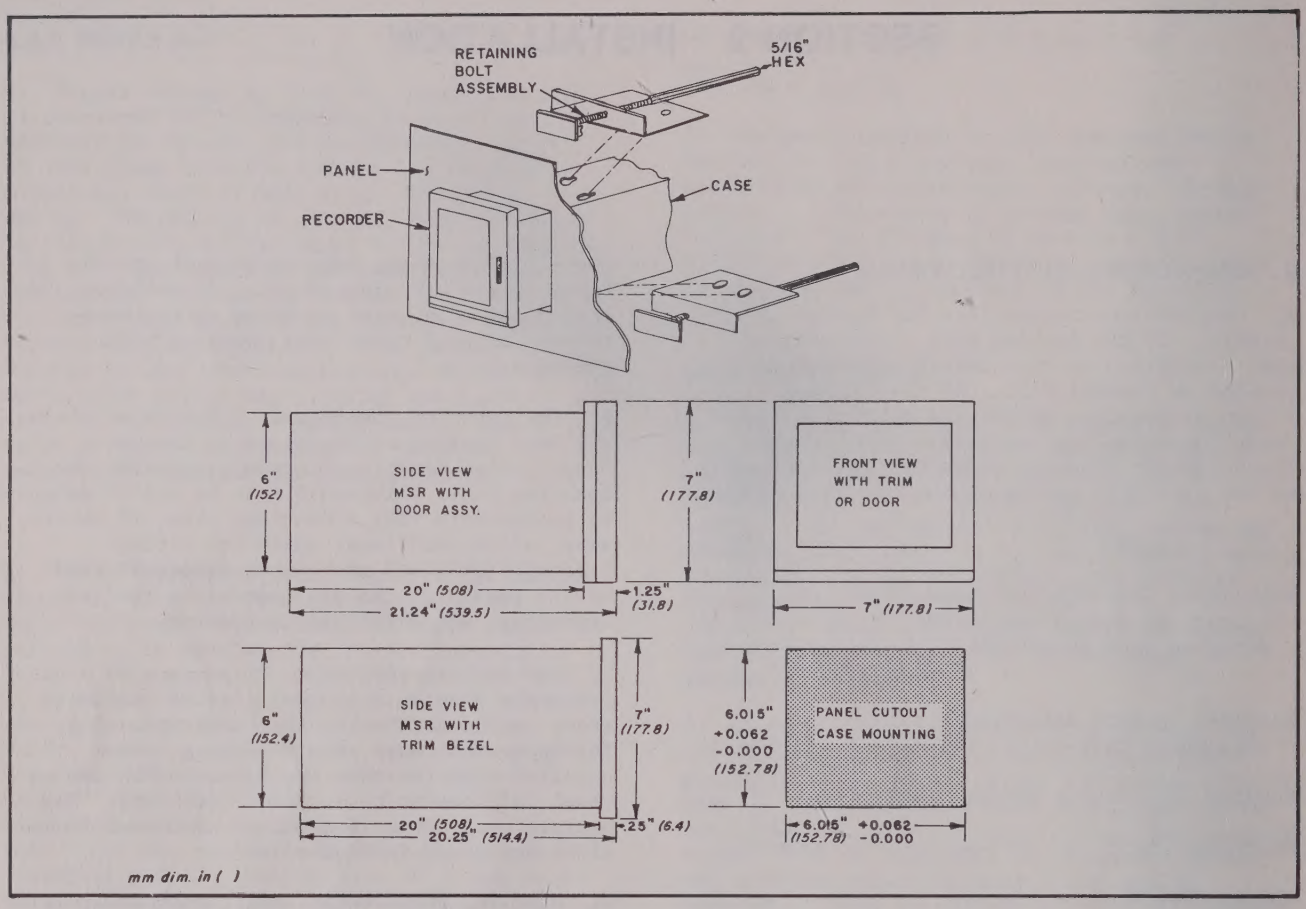


Figure 2-1. Physical Dimensions and Case Mounting.

(4) Press down on chassis latch at lower, right-hand corner of case. While keeping latch depressed, carefully and completely withdraw chassis from case. When chassis is completely out of the case, release chassis latch. Swing chassis slightly to the left and rotate chassis a few degrees in the counterclockwise direction. While cradling chassis in this position with the left arm, reach into the case opening with the right hand and carefully detach the quick-disconnect plug and cable assembly from the rear of the chassis. Chassis is now completely disconnected from the case and may be removed.

(5) Orient case so that case sliderails are toward bottom of cutout. Insert case through front side of panel cutout and slide case inward until case flanges are flush with front of panel.

(6) Attach retaining bolt assembly into slotted holes in bottom of case (see Figure 2-1). Tighten 5/16" hex retaining bolt until secure with nut driver or ratchet wrench. Do not over tighten.

(7) Repeat Step 6 procedure with the retaining bolt assembly attached to top of case.

CAUTION: Panel must be of adequate strength to support instrument. Fabricate additional rear support, if necessary.

(8) If panel is of the removable type, it may now be fixed in its permanent position with the attached case.

(9) REINSTALLATION OF CHASSIS: After case has been mounted, reinstall chassis into case as follows:

(a) Lift chassis in an upright position, and bring rear of chassis into close proximity for entry into case on sliderails. Orient chassis slightly to the left, and rotate chassis a few degrees in the counterclockwise direction. While cradling chassis in this position with the left arm, reach into the case opening with the right hand and attach the flat-ribbon cable connector onto the mating connector at the rear of the chassis.

CAUTION: To ensure proper keying between mating connection, cable should be lying flat without any twists.

(b) Place bottom of chassis onto the case sliderails, keep chassis latch pressed down, and slide chassis completely into case. Release chassis latch to retain chassis in case.

NOTE: The sliding chassis is provided with three detent positions in addition to its fully retracted (chassis lockin) position. When chassis is either being withdrawn or retracted, chassis may be detented to each of its three positions by momentarily depressing the chassis latch and then simultaneously sliding the chassis until it latches.

(10) REINSTALLATION OF CASE DOOR: If door was supplied with the case, reinstall case door as follows:

(a) Lift up on lower-hinge pin in door. Position door so that slot at bottom-hinge side of door slides onto the lower-hinge portion of the case-hinge bracket. Release hinge pin and position bottom of door so that end of hinge pin engages hole provided in lower portion of hinge bracket.

(b) Pull down on upper-hinge pin in door. Position top of door so that slot at top-hinge side of door slides onto the upper-hinge portion of the case-hinge bracket. Release hinge pin and position top of door so that end of hinge pin engages hole provided in upper portion of hinge bracket.

(c) Close and latch door by pressing inward on the upper part of the door latch.

2.3 ELECTRICAL CONNECTIONS

a. The input power and signal input ratings are specified on the instrument data sheet and should be connected to terminals indicated in Figure 2-2.

b. To gain access to rear connection panel, remove four screws from case cover and remove cover.

NOTE: A 250-ohm shunt resistor is provided on rear terminals for 4-20 mA recording. If the MSR or one of its channels is to be used for a 1 to 5 volt recorder, then the 250 ohm resistor MUST BE REMOVED for that channel. See Figure 2-2 for shunt resistor location.

2.3.1 LEAD DRESS

a. After all connections have been made to input panel, dress leads so that they can be routed through cutouts formed in rear cover and bottom of case. To avoid interference problems, dress signal leads away from power and accessory leads.

b. Ensure that all lead connections are clean, tight, and not touching one another. Reinstall rear cover to case with four screws and again dress leads so that they are routed through cutouts in rear cover and bottom of case.

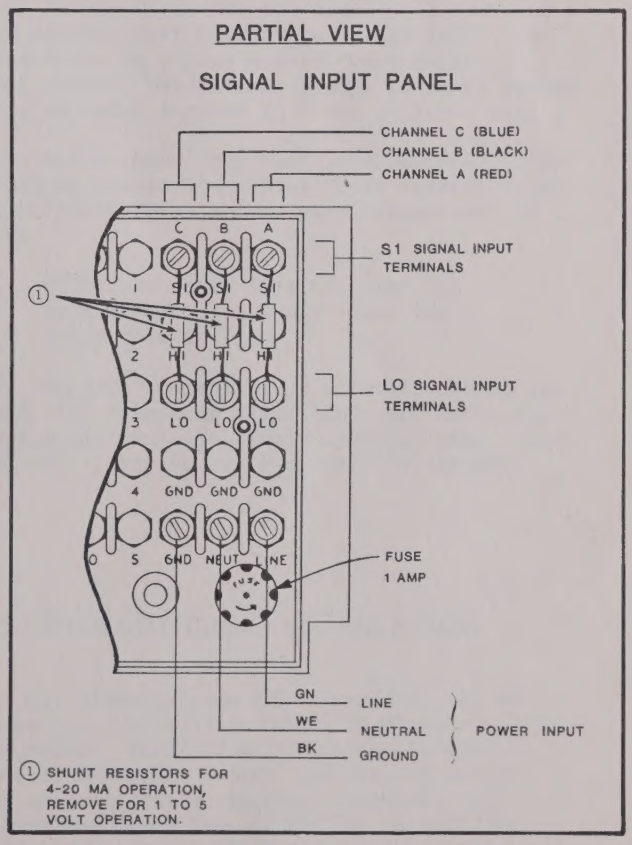


Figure 2-2. Power & Input Signal Connection Points.

SECTION 3 - OPERATION

3.1 GENERAL

This section of the manual includes complete operating procedures for standard Miniservo III recorders. No attempt should be made to operate the instrument until all instructions have been thoroughly studied. The normal care when handling any precision piece of equipment should be exercised.

3.2 CHART LOADING

a. Only Esterline Angus precision charts should be used in this instrument for guaranteed accuracy and optimum performance. To ensure continuous records, inspect the recorder periodically for its remaining chart supply. A blue line will start to appear in the left-hand margin of the chart when approximately a meter or yard of unused chart remains. Always keep enough charts on hand to operate the recorder for at least one month. Charts must be ordered by assigned numbers, which are printed along the right-hand margin on each chart.

b. To install chart paper in the recorder, refer to the chart threading illustration in Figure 3-1 and proceed with the following steps:

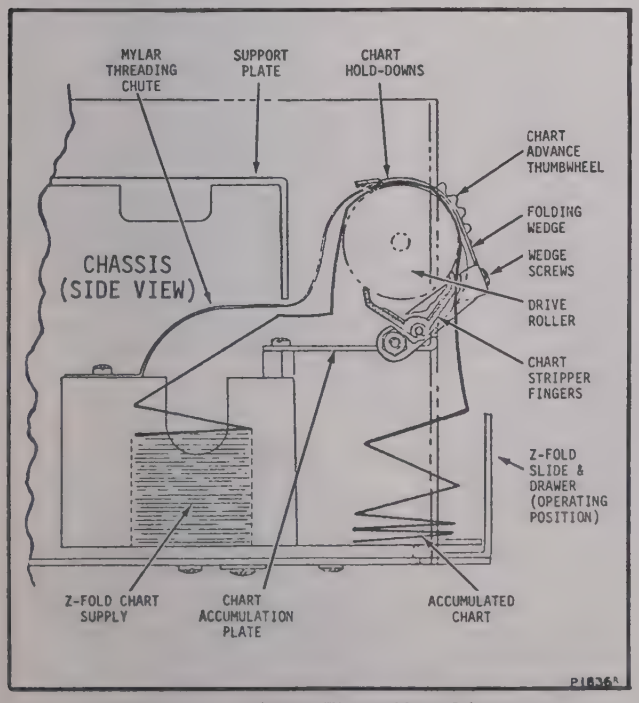


Figure 3-1. Chart Threading Diagram.

(1) Gain access to front of recorder chassis and place Main Power switch in its OFF (left-hand) position. Grasp lower edge of scaleplate and swing plate outward and upward to remove it from top retaining clips.

(2) Move Pen Lift lever down to raise writing elements. Grasp front of chart tray at bottom of recorder and slide tray fully outward until it stops.

(3) Remove Z-fold chart pack from its container. Orient pack so that edge with elongated holes is on left-hand side and printed side of paper will face recorder as chart unfolds from top of pack. Slide pack into rear supply compartment through opening on right side of tray.

(4) Lift out a few folds of chart from top of supply pack and insert leading edge of paper between Mylar threading chute and drive roll.

(5) Rotate Chart Advance thumbwheel downward and thread chart over top of drive roll. See that drive roll pins engage chart holes at both sides. Guide leading edge of chart behind folding wedge located in front of drive roll.

(6) Slide chart tray back into recorder. Continue to rotate thumbwheel until several paper folds enter front accumulator compartment of tray.

NOTE: If chart does not start to fold properly, manually position first fold in tray.

(7) Replace scaleplate by first inserting top edge into retaining clips; and then swing plate down until it snaps firmly into position. Move Pen Lift lever up to lower writing elements.

3.3 INK CARTRIDGE INSTALLATION

a. One piece pen-and-ink cartridges are employed in the writing system of Miniservo III recorders. These plug-in disposable modules come in different colors and pen-tip lengths for each recording channel. Standard ink colors are "red" for channel A, "black" for channel B, and "blue" for channel C. See Figure 3-2A for correct operating position of each channel cartridge.

b. To ensure continuous records, check supply of ink in cartridges when changing charts. Each cartridge holds enough ink for 3600 feet of chart trace. Always keep a supply of cartridges on hand to operate the recorder for at least one month. Replacement cartridges are available in convenient six packs. To install an ink cartridge, proceed with the following steps:

(1) Gain access to front of recorder chassis and place Main Power switch in its OFF (left-hand) position.

(2) Grasp lower edge of scaleplate and swing plate outward and upward to remove it from top retaining clips. Place Pen Lift lever in its upper position to lower cartridge holders.

(3) Remove protective cap from cartridge pen tip and, with pen tip facing down, insert cartridge straight back into cartridge holder. Pen priming is not necessary.

> NOTE: On multichannel models, install shortest pen-tip cartridges first. A piece of paper or blotter may be inserted under pen tips to avoid ink traces on chart.

(4) Replace scaleplate by first inserting top edge into retaining clips; and then swing plate down until it snaps firmly into position.

3.4 OPERATING CONTROLS

a. All basic operating controls are located on the front of the recorder--as shown in Figure 3-2A. Individual control functions are described in the following paragraphs.

b. MAIN POWER SWITCH (S101): This is a two-position toggle switch that controls AC power to the entire recorder. In its ON position, power is applied to the servo measuring system, to the chart drive switch, and to the internal lighting circuit. Always place the switch in its OFF position when recorder is not in use, or when charting, inking or servicing the instrument.

> WARNING: High voltage will always be present within chassis whenever external power and signal leads are attached.

c. CHART DRIVE POWER/SPEED SWITCH (S102): This dual-speed selector switch is a three-position toggle type that controls pulse operation of a DC stepper motor. In its FAST (right-hand) position, the chart drive operates at the fastest chart speed; in its center position, the drive operates at the slowest speed; and in its OFF (left-hand) position, the chart drive is completely de-energized.

d. CHART ADVANCE (THUMBWHEEL): This mechanical adjustment is provided so that the operator can advance the chart paper manually. Rotating the wheel downward overrides the internal drive system and propells the chart forward. This control should always be used when loading chart in the instrument.

e. PEN LIFT (LEVER): The small metal arm located at the left end of the scaleplate is the Pen Lift lever. This device permits the operator to raise or lower the writing elements as desired. To raise the pens from the chart, merely move the lever "down". The pens can be lowered to their recording positions by moving the lever "up".

f. DOOR CATCH: This adjustable metal clasp is mounted on the right-front of the standard recorder case. It is used to hold the case door in a tightly closed position. To open the case door, press inward on the lower part of the door latch. To secure the door, press inward on the upper part of the door latch.

g. CHASSIS LATCH: This metal lever is located in the lower-right corner of the recorder case. It is used to secure the chassis in the case and to provide slide-out stops for various chassis service positions. The chassis is released and free to slide forward by pressing down on the latch. The first slide-out position is for inspection of inking and lighting components; the second position is for inspecting servo systems; and the third position for amplifier card adjustments. The lever must also be actuated to remove the entire chassis from its case.

3.5 AMPLIFIER ADJUSTMENTS

a. All electronic controls in the measuring circuit are carefully set at the factory and will not normally require attention in the field. Certain amplifier adjustments are provided, however, to satisfy various user applications and for recalibration purposes. These adjustments are miniature potentiometers located on the plug-in amplifier board that is supplied for each channel. With recorder

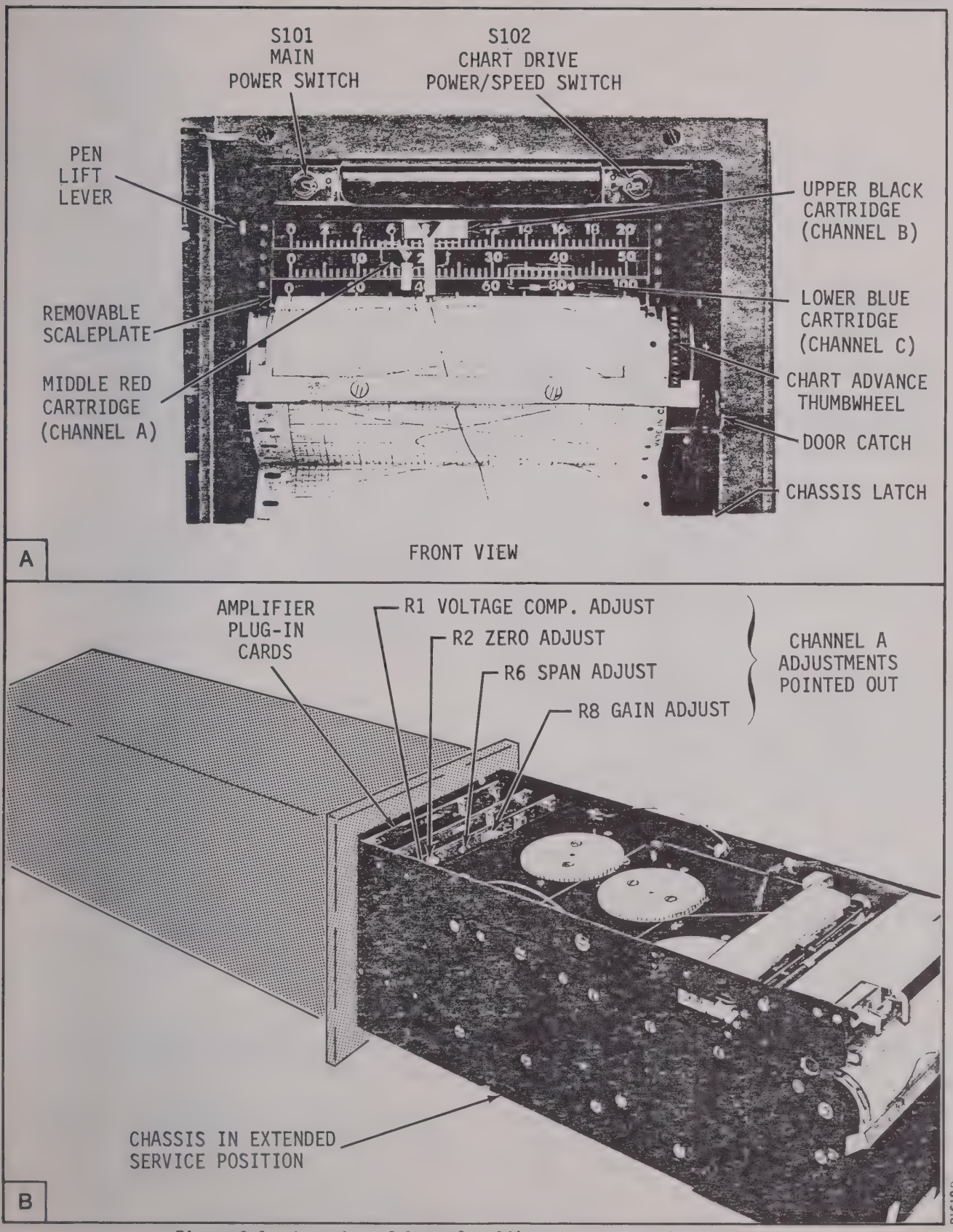


Figure 3-2. Location of Controls, Adjustments, and Ink Cartridges.

chassis in its outer-most service position, each pot may be adjusted with a small screwdriver--as pointed out in Figure 3-2B. Refer to the following paragraphs for a description of each adjustment.

b. ZERO ADJUST (R2): This 15-turn pot provides a means by which the operator can accurately set the recording pen to the zero reference line on the chart when no input signal is applied. It injects an offset voltage into the measuring circuit so that a zero shift of approximately ±50% of chart span can be obtained. The adjustment is preset at the factory to a -20% of span, which represents the proper zero supression for signal ranges of 1-5V DC or 4-20mA DC.

c. GAIN ADJUST (R8): This single-turn pot is used to establish an overall amplification level for the internal measuring circuit. Servo "stiffness" (deadband) is determined by the setting of this amplifier adjustment. It should be set for minimum deadband with maximum stability.

d. SPAN ADJUST (R6): This is a 15-turn amplifier adjustment that determines the accuracy of full-span calibration. It is used to regulate the precise amount of reference supply voltage that is applied across the servo feedback potentiometer. The Span Adjust provides a shift at full-scale of approximately 10%, but it should be adjusted only during calibration procedures.

e. VOLTAGE COMP ADJUST (R1): This calibration adjustment is used to null-out any voltage offset inherent in the preamplifier stage due to op-amp drift. It is a 15-turn trim pot that is adjusted only during calibration procedures for a zero op-amp output with signal input terminals shorted.

3.6 DUAL-SPEED CHART DRIVE

a. This feature of the Miniservo III recorder is comprised of the three following major elements: a three-position chart drive power/speed switch (S102), the stepper drive PC board and the stepper chart drive motor (B101). Locations of these components are identified in Figure 1-1.

b. Refer to Table 1-1 for technical specifications relating to the stepper chart drive and for other standard recorder specifications.

3.6.1 DUAL-SPEED SELECTION

a. Either a "slow" or a "fast" chart speed is selected by positioning of the chart drive power/speed switch (S102). The extreme left-hand position turns the stepper drive "off", the center position selects the "slow" chart speed, and the extreme right-hand position selects the "fast" chart speed.

b. As listed in the specifications of Table 1-1, any one of four "slow" speeds and any one of seven "fast" speeds is preset at the factory by manually prepositioning two jumper wires on the stepper drive PC board. These two jumpers are prepositioned to select the dual-speed (slow/fast) feed rates specified by the user. The specified slow/fast rates of chart speed are listed on the instrument Data Sheet.

c. In summarizing then, the "slow" and "fast" positions of the front panel chart drive switch select the two preset speeds that are made with the two internal jumpers. If it is desired to change the slow/fast feed rates in the field, refer to topic heading "Changing Chart Drive Speeds".

3.6.2 CHANGING CHART DRIVE SPEEDS

If it is desired to change to a different slow/fast chart speed than was originally preset, it is necessary to gain access to the stepper drive PC board as follows:

(1) Completely remove recorder chassis from panelmount case by following instructions given in the Installation Section of this manual.

(2) After chassis is removed from case, locate stepper chart drive PC board at rear of chassis.

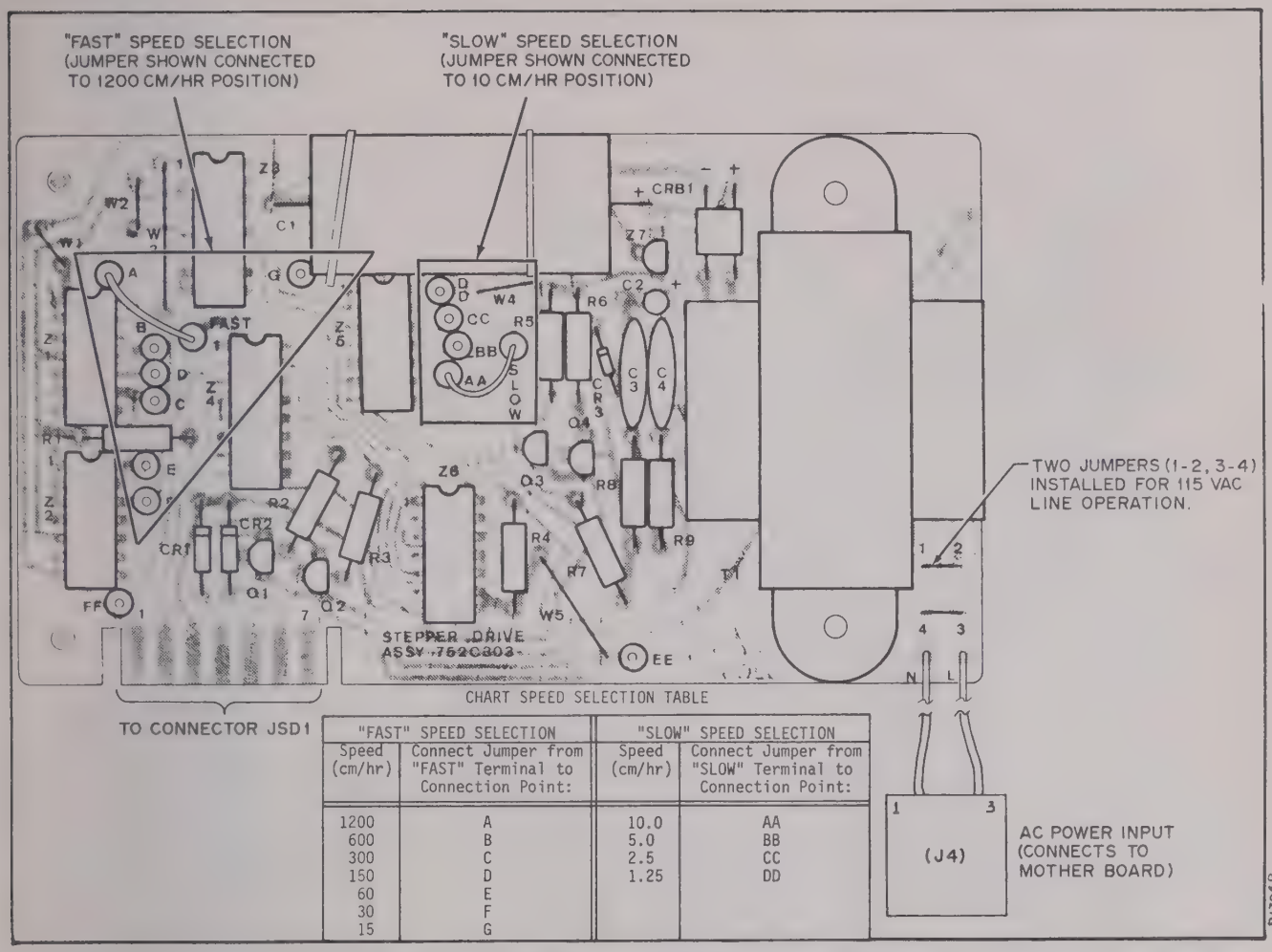


CHART SPEED SELECTION TABLE

"FAST" SPEED SELECTION		"SLOW" SPEED SELECTION	
Speed (cm/hr)	Connect Jumper from "FAST" Terminal to Connection Point:	Speed (cm/hr)	Connect Jumper from "SLOW" Terminal to Connection Point:
1200	A	10.0	AA
600	B	5.0	BB
300	C	2.5	CC
150	D	1.25	DD
60	E		
30	F		
15	G		

Figure 3-3. Top View of Stepper Drive PC Board.

(3) Refer to Figure 3-3, select desired chart speeds from "Chart Speed Selection Table", and make appropriate jumper connections to designated connection points on stepper drive PC board.

(4) Reinstall chassis into panelmount case as instructed in Installation section of this manual.

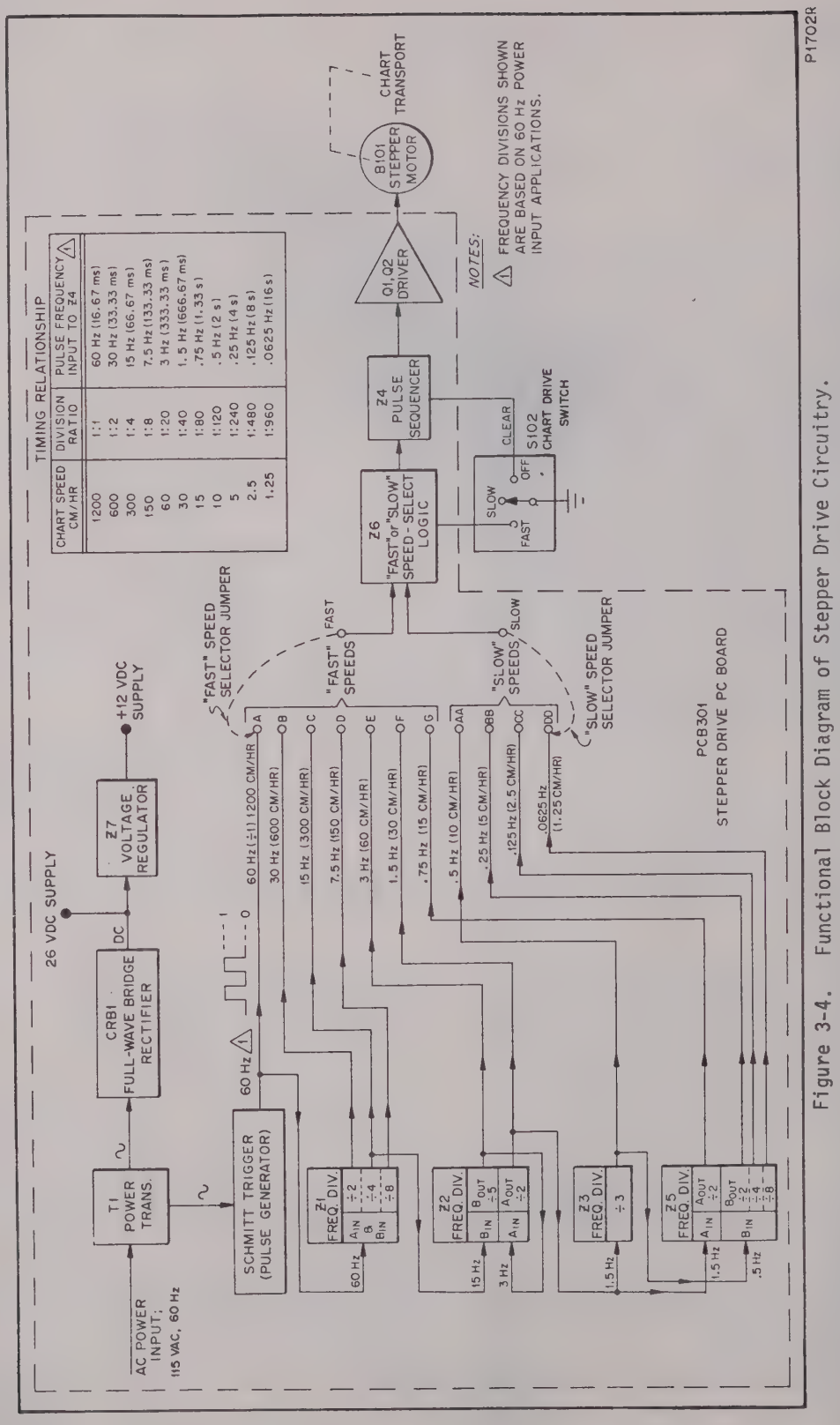
(5) Apply power to recorder, place chart drive power/speed switch in the desired chart-speed position (slow or fast), and check to see that chart travels at the new rate preset by the jumper connections.

NOTE: When different slow/fast chart drive speeds (i.e., different ones than were originally specified on the instrument Data Sheet) are preset by the manual jumpering, it is advisable to keep a written record of the latest combination of slow/fast speeds for future reference.

3.6.3 STEPPER DRIVE CIRCUIT DESCRIPTION

a. A function block diagram of the stepper drive circuitry is shown in Figure 3-4. Refer to this figure when following the circuit description.

b. With the exception of the stepper motor (B101) and chart drive switch (S102), all stepper drive circuitry is self-contained on the stepper drive PC board shown in Figure 3-3.


TIMING RELATIONSHIP
CHART SPEED CM/HR
DIVISION RATIO
PULSE FREQUENCY INPUT TO Z4
1200 1:1 60 Hz (16.67 ms)
600 1:2 30 Hz (33.33 ms)
300 1:4 15 Hz (66.67 ms)
150 1:8 7.5 Hz (133.33 ms)
60 1:20 3 Hz (333.33 ms)
30 1:40 1.5 Hz (666.67 ms)
15 1:80 .75 Hz (1.33 s)
10 1:120 .5 Hz (2 s)
5 1:240 .25 Hz (4 s)
2.5 1:480 .125 Hz (8 s)
1.25 1:960 .0625 Hz (16 s)
AC POWER INPUT; 115 VAC, 60 Hz
T1 POWER TRANS.
CRB1 FULL-WAVE BRIDGE RECTIFIER
26 VDC SUPPLY
Z7 VOLTAGE REGULATOR
+12 VDC SUPPLY
SCHMITT TRIGGER (PULSE GENERATOR)
60 Hz
"FAST" SPEED SELECTOR JUMPER
"FAST" SPEEDS
"SLOW" SPEEDS
"SLOW" SPEED SELECTOR JUMPER
60 Hz (±1) 1200 CM/HR
30 Hz (600 CM/HR)
15 Hz (300 CM/HR)
7.5 Hz (150 CM/HR)
3 Hz (60 CM/HR)
1.5 Hz (30 CM/HR)
.75 Hz (15 CM/HR)
.5 Hz (10 CM/HR)
.25 Hz (5 CM/HR)
.125 Hz (2.5 CM/HR)
.0625 Hz (1.25 CM/HR)
Z1 FREQ. DIV.
Z2 FREQ. DIV.
Z3 FREQ. DIV.
Z5 FREQ. DIV.
Z6 "FAST" or "SLOW" SPEED - SELECT LOGIC
Z4 PULSE SEQUENCER
Q1, Q2 DRIVER
B101 STEPPER MOTOR
CHART TRANSPORT
S102 CHART DRIVE SWITCH
SLOW
FAST
OFF
CLEAR
PCB301 STEPPER DRIVE PC BOARD
NOTES:
⚠ FREQUENCY DIVISIONS SHOWN ARE BASED ON 60 Hz POWER INPUT APPLICATIONS.

P1702R

Figure 3-4. Functional Block Diagram of Stepper Drive Circuitry.

c. External line-synchronous AC power is applied to the primary of recorder power transformer T1. The secondary of this transformer developes approximately 20-volts AC that operates the entire stepper drive circuitry.

d. The stepped-down secondary voltage of T1 is applied to a full-wave bridge rectifier CRB1 where the AC is rectified and filtered to provide an unregulated 26-volt DC source. The 26-volt source powers the output driver stage (Q1,Q2).

e. The 26-volt source is also applied to a voltage-dropping and voltage-regulating integrated circuit Z7. This IC has built-in thermal overload and short-circuit protection; its output is further filtered to provide an output supply of 12 volts DC. The 12-volt source powers the Schmitt trigger circuit and all of the logic circuits.

f. The time base for the stepper drive is coupled from the secondary winding of power transformer T1 and is applied to a Schmitt trigger circuit. The Schmitt trigger functions as a bistable multivibrator to convert the AC sinusoidal input waves into DC logic pulses (rectangular waves). Since the Schmitt trigger is synchronized to the applied input line frequency, a basic pulse rate of 60 Hertz is established.

g. After generation of the 60 Hz rectangular wave pulses by the Schmitt trigger, the basic frequency is then divided down through a series of frequency-divider circuits consisting of CMOS IC's Z1, Z2, Z3 and Z5. Integrated circuits Z1 and Z5 are 4-bit binary counters, Z2 is a 4-bit decade counter, and Z3 is a dual J-K flip-flop with clear and preset inputs. The outputs of the frequency dividers provide the pulse frequencies which determine the various stepper chart speeds in cm/hr. Refer to "Timing Relationship" table in Figure 3-4 .

h. All of the frequency-divider outputs are brought out to connection points on the PC board where the positioning of two separate jumpers on the board selects one "fast" and one "slow" chart speed. The "fast" speed-selector jumper may be connected to one of seven positions on the board to select one out of seven "fast" chart speeds. The "slow" speed-selector jumper may be connected to one of four positions on the board to select one out of four "slow" chart speeds.

i. The one "fast" chart speed and the one "slow" chart speed selected by the jumpers are then applied to the speed-select logic circuit of Z6. Integrated circuit Z6 is a quad 2-input NOR gate that operates in conjunction with the chart-drive switch (S102). When the chart-speed switch is in its "slow" position, the pulse frequency selected by the "slow" speed-selector jumper is gated through to the pulse sequencer Z4. When the chart-drive switch is in its "fast" position, the pulse frequency selected by the "fast" speed-selector jumper is gated through to the pulse sequencer Z4. When the chart-speed switch is in its "off" position, the "clear" input of Z4 is held "low" and stops the flip-flop action of Z4.

j. One of the dual J-K flip-flop circuits of Z4 is used as the pulse sequencer and serves to alternately pulse the stepper motor B101 through output driver switching transistors Q1 and Q2. The DC output pulses from the driver circuitry are applied in sequence to the two windings of stepper motor B101. The 26-volt stepper motor is designed with a permanent-magnet rotor and an electro-magnetic stator. It rotates in discrete angular steps of 15 degrees and is capable of stepping 80 times a second.

3.7 OPERATING PROCEDURES

The following basic operational steps assume that initial installation procedures have been completed, chart paper is installed, and that the inking system for each channel is ready for use.

(1) Gain access to front of recorder chassis, place Chart Drive switch in its OFF position, and place Main Power switch in its ON position. A five- to ten-minute warmup is recommended for amplifier stabilization.

(2) To remove scaleplate, grasp lower edge and swing plate outward and upward. Lower Pens onto chart by moving Pen Lift lever up. Place Chart Drive switch in its center (slow-speed) position to conserve chart.

(3) With external analog source connected and a 1-volt signal applied, channel pen should rest on "0" reference line of chart. If it does not, slide out chassis to extended service position and carefully reset Zero Adjust R2. DO NOT disturb other amplifier card adjustments.

NOTE: If recorder is connected directly to a current source, a 4.0 mA signal should be applied as a "0" reference.

(4) Repeat step 3 for other active channels. Place Chart Drive switch in desired speed position.

CAUTION: Internal over-range protection is limited to 100 volts. Maximum common-mode potential is 120V AC or ±150V DC.

(5) Recorder is now operational. Replace scaleplate by first inserting top edge into retaining clips; and then swing plate downward until it snaps into position.

3.8 MAINTENANCE

a. The design features of the Miniservo III Recorder provides for long, trouble-free operation and low-maintenance requirements. However, to ensure optimum performance, it is good practice to establish and follow a periodic maintenance schedule. Where extreme temperatures or contaminated atmospheres prevail, maintenance should be performed more often. Since instrument usage and environmental conditions may vary with each application, maintenance scheduling is left to the discretion of the user.

b. Routine maintenance procedures will primarily entail a complete visual inspection and cleaning. For reference purposes, keep a simple record on usage of accessory items as scheduled inspections are made. An inventory will help ensure that a ready reserve of expendable items, such as chart paper and pen modules, is kept in stock.

WARNING: Prior to servicing or cleaning activities, always make sure that instrument power is turned off.

3.8.1 INSPECTION

a. A complete visual inspection of the instrument should be made at each scheduled maintenance period to detect the possible onset of a malfunction or the need for a new chart or ink cartridge.

b. Extend chassis out to the service position (see Figure 3-2), and check for the following: low chart supply, low ink supply, accumulation of dirt, damaged or loose hardware, loose wire connections/connectors, loose plug-in cards, and shorted or broken wiring. Also check the reserve of charts and ink cartridges to ensure that an adequate supply is on hand.

3.8.2 CLEANING

a. Regardless of the precautions taken, dirt and dust will enter the panelmount case and recorder chassis areas; therefore, periodic cleaning of exposed components on the chassis and within the case may be necessary. Always keep pen tips free of lint and dried ink. To prevent possibility of "dry-out", replace protective caps on pen tips if recorder remains inactive for more than 24 hours.

b. Light dirt marks can be removed from chassis and case surfaces, the chassis scaleplate, and other frontal chassis areas with a damp, lint-free cloth or sponge. Heavier dirt smudges can be removed with any commercially-available liquid detergent; however, DO NOT use harsh solvents since they may damage certain finishes. Esterline Angus recording ink is water-based and can be removed with a wet cloth. Dust and other dry accumulations can be removed from within the recorder with a soft-bristled brush or low-vacuum system.

CAUTION: Exercise care when cleaning to avoid disturbing electrical wiring and alignment of mechanical parts.

3.8.3 SHUTDOWN

If the recorder is to remain inactive for more than 30 days, disconnect AC power and remove pen cartridge modules. If cartridges are to be retained, place protective caps over pen tips. If instrument is to be transported for a long distance, follow factory-packing procedures.

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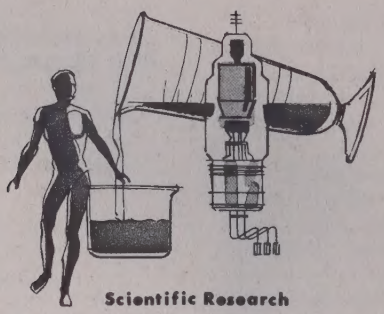
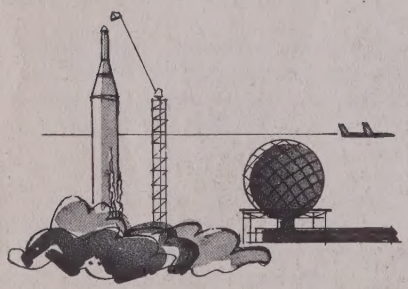
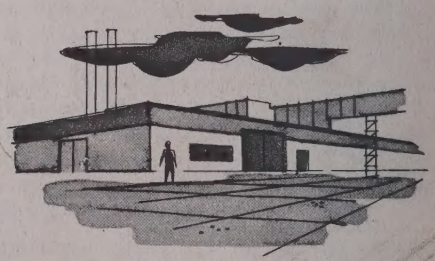


Scientific Research



Space Exploration



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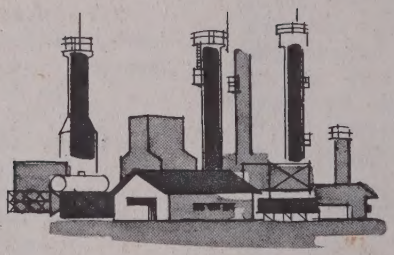

Process Monitoring and Control

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